Evaluation of the effect of intact casein on melting properties of process Cheddar cheese

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Introduction

Process cheese is a food made through the heating and agitation of natural cheese, emulsifying salts, and other optional ingredients (milk, whey, cream, and acid). As natural cheese ages, its casein proteins gradually break down due to enzyme activity, resulting in lower levels of intact casein compared with young cheeses. Process cheese makers vary the ratio of young to old cheeses to produce a product with the desired amount of intact casein. The amount of intact casein affects the texture of the process cheese; too much intact casein results in process cheese that is too firm but too little intact casein results in process cheese that is too soft. The texture also affects the melting properties of process cheese.
The processing conditions (in particular cooking temperature and mixing speed) influence emulsion stability and therefore also effect the melting properties of process cheese.

Objective

The objective of this project was to explore the influence of intact casein, cooking temperature, and mixing speed on the melting properties of process Cheddar cheese.

Results

Table 1. Results from RVA melt tests for samples made with various levels of intact casein and processing conditions.

Intact Casein(%)	Temperature (°F)	Mixing Speed (rpm)	Melt Time (min.)	Hot Viscosity (cP)	Time at 5000 cP (min.)	Solidification Time (min.)
14.0	170	75	5.7	463	10.6	12.6
14.0	190	75	5.9	563	10.7	12.2
14.0	170	350	5.5	438	10.8	12.3
14.0	190	350	5.7	525	11.1	12.3
15.5	170	75	6.3	475	11.1	11.8
15.5	190	75	5.9	567	11.2	11.6
15.5	170	350	6.0	525	10.4	11.6
15.5	190	350	6.2	517	10.6	11.8

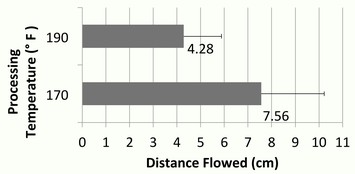


Figure 1. Relationship between processing temperature and flow distance in the tube melt test.

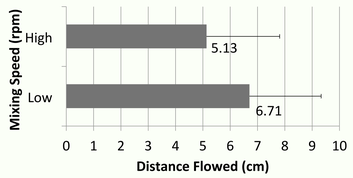


Figure 2. Relationship between mixing speed and flow distance in the tube melt test.

Image 1. Typical processing steps in the production of process Cheddar cheese.

Methods

Samples of process Cheddar cheese were obtained from South Dakota State University. Samples varied on intact casein content (14.0% / 15.5%), cooking temperature (170° F / 190° F), and mixing speed during processing (75 rpm/ 350 rpm). Melting properties were evaluated using the following tests:

1. Rapid Visco Analyzer (RVA) Test[1]
- 25 grams of each sample (cut into 1 cm cubes) was placed in an RVA canister and analyzed using a 14-minute melting/cooling program. Samples were heated from 25 to 90° C over 9 minutes, held at 90° for 3 minutes, then cooled to 25° over the final 6 minutes.
- Viscosity was measured throughout the test, and resulting curves were used to determine the melting time, solidification time, and hot viscosity of the samples.

2. Tube Melt Test[1]
- 20 grams of each sample was blended into a paste and pressed to a set line in a glass tube. Tubes were placed in a forced draft oven at 110° C for 10 minutes, then removed and inverted to cool.
- The distance of cheese flow from the etched line was measured.

3. Fat Ring Test using Computer Vision[2]
- Samples were sliced to a thickness of ¼ in. using a mandolin, cut into 17-mm disks, and heated on filter paper in a forced draft oven at 110° C for 10 minutes.
- A computer vision system was used to capture the images and determine the area of the oil ring produced.

Figure 3. Relationship between oil ring size and processing temperature determined using the fat ring test.

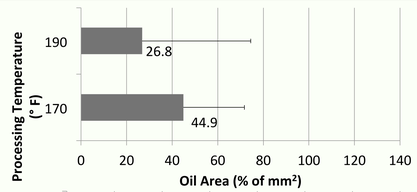


Figure 4. Relationship between oil ring size and intact casein determined using the fat ring test.

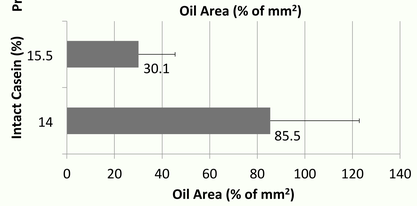
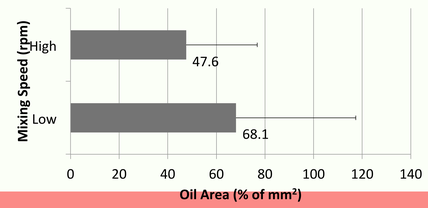


Figure 5. Relationship between oil ring size and mixing speed determined using the fat ring test.



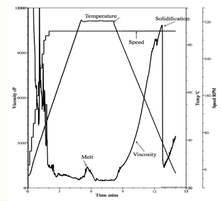


Image 2. Melting curve generated during RVA melt tests.

Image 3. Tubes in a forced draft oven during the tube melt test.

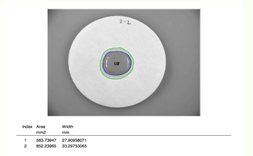


Image 4. Sample after melting during the fat ring test. The outer ring shows the area of the oil and the inner ring shows the area of the melted cheese.

Conclusions

Effect of intact casein
- Samples with lower amounts of intact casein had on average a shorter melting time, longer solidification time, and larger oil area. No significant difference was observed in flow distance during melting.
- As cheese ripens and casein is broken down, the texture softens and melting becomes easier.
- Proteolysis affects the emulsion stability of process cheese. As cheese ages, emulsion stability is expected to increase as the fat globules increase in number and decrease in diameter[3]. At a certain level of proteolysis, however, emulsion stability will decrease and more oil will escape.

Effect of cooking temperature
- Samples processed with lower cooking temperatures had on average a greater flow distance and oil area.
- These results were not expected. It was hypothesized that as temperature increased a change in the protein structure would restrict structure-forming interactions, resulting in a softer cheese with increased melting ability[4].

Effect of mixing speed
- Samples processed with lower mixing speeds had on average a greater flow distance and oil area.
- These results were consistent with the expected results; at higher speeds, fat globule particle size was reduced, which allows for improved emulsification though improved protein-protein interactions[5].

Knowledge about how product formulation and processing parameters affect process cheese is important for the optimization of process cheese manufacture. This knowledge also allows for production of process cheese that fits the melting specifications desired for specific applications.

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References

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